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A STUDY OF RESIDENTIAL STORMWATER IMPOUNDMENTS: PERCEPTIONS AND POLICY IMPLICATIONS[1]

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ABSTRACT: The traditional solution to stormwater runoff from housing developments has been stormwater sewer systems. A newer and increasingly popular solution is some sort of impoundment or "lake" within the development, which is thought to be cheaper, to provide recreation, to improve the aesthetics of the environment, and to increase property values. Little is known of the acceptability of these to public officials, developers, or potential residents, or of their policy implications. Two such developments in Mississauga, Ontario, were studied, in terms of the perceptions and opinions of a random sample of residents and of officials who had been involved in their planning and management. The areas have attracted a relatively young group, just beginning their child-bearing years, with relatively high income and education. The lakes appear to be popular, and relatively successful, especially the one which provides more recreational opportunities, and which has had fewer maintenance problems. The major problems are visual and safety. The City, and to some extent the developers, are seen as the appropriate groups to manage and maintain the lakes. Some suggestions, based on residents' and officials' responses, are presented for future designs and policy formulation.
(KEY TERMS: stormwater impoundments; retention/detention ponds; stormwater lakes; policy, stormwater lakes; management; residential satisfaction.)

INTRODUCTION

The role of urban stormwater runoff in flooding downstream is well established, and recently its role in transporting pollutants has also been recognized. The traditional practice of piping runoff into the nearest watercourse is starting to give way to different types of storage techniques. One which is gaining popularity in Canada and elsewhere is the use of stormwater impoundments (stormwater lakes or detention/retention ponds) as part of housing developments. This is thought to improve the aesthetic quality of the environment, to provide recreational opportunities for residents, and to increase the value and resale potential of the homes. A number of such developments have been created during the past 15 years, and others are either planned or in progress.

To date, the bulk of research on stormwater lakes has concentrated on their physical and hydrological characteristics. Only one related study, that of Debo (1977), has been published. He conducted an attitude survey of residents living around man-made lakes in an urban environment in the United States, but these lakes were not designed as stormwater impoundments.

There is a need to develop policies consistent with the proper design, location, and maintenance of such developments; to do so will require acceptance by public officials and potential residents. As the International Reference Group on Great Lakes Pollution from Land Use Activities (1978) has said, of alternatives to storm sewers,

> "Implicit in this new approach are techniques not previously used extensively in Ontario. Some of these techniques, including surface retention/detention ponds . . . will require a high degree of public acceptance not only to ensure the commitment of municipal officials, but also to maintain the long term integrity of these measures."

The purpose of this study was to investigate the perceptions of residents, developers and public officials. It is hoped this information will be useful to policy makers at various levels of government, to developers and to potential residents.

THE MISSISSAUGA DEVELOPMENTS

Lakes Aquitaine and Wabukayne are stormwater impoundments located in the Meadowvale area of the City of Mississauga. About 50 percent of the housing is semi-detached; in Wabukayne, the remainder is mostly single-family dwellings, and in Aquitaine the remainder is mostly apartments. The population of Meadowvale is currently about 26,000 and when the development is complete in the mid-1980s, it will be about 40,000.

Lake Wabukayne was built in 1975 on the site of an existing farm pond as a sediment control device and as a visual amenity (Hough, no date). The catchment area is approximately 1,050 acres (425 hectares). Water movement is controlled by a siltation pond and inlet and outlet dams within

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an overflow and spillway design. The lake itself is relatively small, with a surface area of about 4.3 acres (1.7 hectares). Much of the shoreline was left in a natural state, with steep banks and the original vegetation. Recreational facilities were largely limited to footpaths around the lake, encouraging more passive forms of recreation such as walking, tobogganing, cross-country skiing, and skating. Since the lake was designed as a sediment trap, the City prohibited swimming, boating, and fishing.

Lake Aquitaine is a more recent development, begun in 1976; the residential development is not yet completed. This lake is larger than Lake Wabukayne, but has a smaller catchment area; the lake surface is about 10.5 acres (4.3 hectares) and the catchment area about 265 acres (107 hectares). The engineering works include an inlet dissipator, a surface skimmer, a silting pond and weir, a clay lined bottom, and an earth-fill dam and spillways (Project Planning Associates, 1978). Lake Aquitaine was designed to provide recreational and visual benefits as well as flood and pollution control. Park and recreational facilities include a concession stand, boat-rental, benches and lights. Although swimming is prohibited, non-motorized boating, fishing and skating are allowed. Many community groups, including the residents' association and various service clubs, organize lake-side activities for residents. There have been some management problems at Wabukayne; it has had to be dredged, and some sewer lines which were emptying into the lake had to be rerouted. As a result, there were unanticipated costs, and conflict between residents through the residents association, the City and the developer. These problems arose partly because of the pioneering nature of the development.

Due to the relative lack of experience with stormwater lakes, the cost of maintaining them is not yet established, and estimates of the cost vary widely. An agreement was signed between the City and the developers, by which the latter would be responsible for the maintenance of the lakes for ten years. An annual allowance, adjusted yearly, is paid by the City to the developers to offset maintenance costs.

STUDY DESIGN

Since the lakes are quite different in function, size and design, and since distance from a lake would be expected to have a marked influence on use and perception (Debo, 1977), resident subjects were chosen from four areas: close to (five minutes walk or less) and further from (five to ten minutes walk) Lake Aquitaine, and close to or further from Lake Wabukayne. These areas will be referred to in the tables as A5, A10, W5, and W10. (These study areas are not isomorphic with the formal boundaries of the developments; some of those households living further from Lake Wabukayne – W10 – are in the Aquitaine development.) A sample of 200 households, 50 from each area, was chosen randomly. These residents were interviewed in person (a few who were unwilling to do this were interviewed by phone). An attempt was made to interview all adults in the household together, on the assumption that the household is the decision-making unit.

The resident interview included standard demographic questions on family structure, age, education, occupation, income, and tenancy. Another set of questions concentrated on perceptions of the lake and the community. These items were chosen and designed to facilitate the construction of a Guttman scale of satisfaction with the local environment, hereafter called the Environmental Satisfaction Scale (ESS). (This scale will be discussed in more detail later.) The last set of questions was related to policy and included such issues as who should be responsible for management and for maintenance costs, and whether alternative approaches to dealing with stormwater were preferred to Lakes Aquitaine and Wabukayne.

Similar interviews were conducted with 12 officials. Ten were engineers and planners associated with the City, the developers, and the regional and provincial governments, and two were community members, a representative of the residents association and an editor of a local newspaper. Additional background information was obtained from secondary sources: three local newspapers, City council minutes and real estate publications.

DEMOGRAPHIC FINDINGS

Generally speaking, the residents are relatively young, with heads of household having a median age in the low 30s. Most residents (83 percent) are married, and about half have children, most of them elementary school age or younger. The occupational status, education and income of residents are relatively high; 62 percent are professionals or white collar, 40 percent have some university education, and the median income is $33,000 a year (C$, 1981). This appears to be a relatively homogeneous population of what one might call upper middle class people who are just beginning their child-bearing years. The major differences among the four areas are between those living closer to Lake Aquitaine and the other three. In the former, which has the greatest number of apartments, the percentage married is somewhat lower and there are fewer children (48 percent as compared with 66-78 percent in the other areas). Aquitaine has fewer homeowners than Wabukayne – 55 percent vs. 89 percent.

ATTRACTION OF LAKES FOR POTENTIAL RESIDENTS

Residents were asked if either of the two lakes was a factor in their decision to move to the developments (Table 1). Those living nearer the lakes were, not surprisingly, more likely to say that "their" lake was a factor. The experience of living in the area, however, seems to have had considerable influence on perception. When asked if they would look for a new home near such lakes, the number favoring the lakes increased. However, those living closer to the lakes had become less favorable to "their" lake, and those living further away more favorable. The general increase in the attraction of the lakes

was largely due to the dramatic increase in interest in the "other" lake.

TABLE 1. Lakes a Factor in Moving to Meadowvale, or in Future (percent).

	Area A5	Area A10	Area W5	Area W10
Aquitaine a Factor	50	36	20	22
Wabukayne a Factor	10	10	52	20
Aquitaine, Future	44	52	66	52
Wabukayne, Future	38	48	40	33

Most residents report that they did not realize the lakes were used for storing stormwater before they moved in or that the water could become more polluted over time, but most said that they would have moved to the area anyway. There were no significant differences in responses among the four areas on these questions. Officials were, as one might expect, more aware of the quality of the water. Most thought, correctly, that residents were not aware that the lakes were used to store stormwater, or that pollution could increase.

Those residents whose homes did not back on the lakes (N=175) were asked if they would be willing to pay more for their home or more rent to be closer; only 17 percent were. However, these residents are more likely to feel that there are too many homes around the lakes; this suggests that they see more development cutting off their access. Officials generally did not feel that crowding was a problem, now or in the future when development is complete around Lake Aquitaine. Homeowners were asked if they thought the presence of the lake increased the value of their homes. Almost half (49 percent) said it did; this feeling was strongest among those living closer to Wabukayne. Officials also felt that the presence of the lakes increased property values.

COMMUNITY FEELING

Most residents thought the lakes encourage neighborliness, or a sense of community; this is particularly true in Aquitaine. Most residents (77 percent) report knowing some of their neighbors; only 30 percent knew someone before they moved there. Seventy-five percent of parents report their children have friends in the area. Type of housing, ownership, and household composition did not have any relationship to having friends in the area, but living in the area longer, and belonging to a social or environmental group involved with the lakes, did.

When asked if there were organized groups concerned with social activities or environmental conditions in the area, residents in Aquitaine perceived more groups to be social then environmental (41 percent vs. 22 percent), while the reverse was true in Wabukayne (28 percent vs. 48 percent). This shows a fairly high degree of awareness among residents, and is in accord with the perception of Lake Aquitaine as a recreational and social amenity. The Lake Wabukayne emphasis on environmental groups probably is due in part to the mobilization of residents to solve problems with lake water quality in the past few years.

Although both developments are relatively new, the results suggest that a sense of community is developing. There appears to be a core of residents who have friends around their lake and who have met these people since they came to the area. This implies that over time active involvement with neighbors is fostering the growth of community. Officials generally shared the view of residents that the lakes encouraged a neighborhood-community atmosphere.

PERCEIVED BENEFITS

In general, Lake Aquitaine was seen as providing more benefits (74 percent), with substantial numbers of Wabukayne residents indicating they also received benefits from Aquitaine (70 percent). This reflects the variety of activities available at Aquitaine and its relatively short distance away. The opposite was not true; only a few people (10 percent) at Aquitaine indicated they received any benefits from Lake Wabukayne.

The lakes are much-used for recreation in both summer and winter. Distance from the lakes is a factor in winter use, those further away using them less. Officials were aware of this. Aquitaine was considered a focal point for the community, used for a wide variety of community activities, while Wabukayne is considered more localized, serving primarily that neighborhood.

The lakes are also used as play areas by children. About half the parents thought their children played around the lakes. Pre-school children were significantly less likely to do so than older children. This was especially true at Wabukayne, probably because the slopes of the Lake are quite steep, and there is less park area.

Residents are about equally divided on whether or not more recreational facilities should have been provided around the lakes, and there were no significant differences among the four areas. However, when asked if more areas around "their" lake should have been left in a natural state, there was a difference. Wabukayne residents were equally divided on the issue, but 70 percent of Aquitaine residents thought there should have been more natural areas left around "their" lake. This is supported by the finding that, while 86 percent of the sample said the scenery was important to them, scenery was significantly more important to those in Wabukayne, especially those closer to the lake.

Among officials, there was considerable agreement with residents on the aesthetic and recreational functions of the two lakes. Provision of additional recreational facilities does not seem, however, to be of concern to most; they feel the facilities are adequate.

PERCEIVED PROBLEMS

Residents were asked both unstructured and structured questions about the problems with the lakes (see Tables 2 and 3). Visual and safety problems were most commonly mentioned spontaneously by residents. It would appear that the visual problems are largely those of murky water and algae. Moreover, there are clearly more problems at Wabukayne and, except for the problem of garbage in the lake, distance from the lakes does not significantly affect perception of the problems. The officials cited various problems with the lakes, murky water being the most commonly mentioned. The sediment trap in Lake Aquitaine was considered adequate, but at Lake Wabukayne the sedimentation and resulting murky brown water were considered an ongoing problem. As noted before, the siltation problems became so serious at Lake Wabukayne at one point that the lake had to be dredged. Aquatic growth in the lakes is expected to increase, affecting the aesthetics of the area. Most officials felt that at present odor is a problem only at Wabukayne. Insect problems are considered common to the entire Meadowvale area, and not necessarily related to the lake environment. Concern for the safety of children around the lakes was a common response of City officials and developers of both lake areas. (There was one drowning at Aquitaine before it officially opened.) The gentle slopes and boulders at Aquitaine were mentioned as safety features by the Aquitaine developers. Officials were more concerned with vandalism than the residents. Many mentioned it has been a problem, particularly at Lake Aquitaine where facilities have suffered some damage.

TABLE 2. Unstructured Questions: Problems Cited by Residents (percent).

Problem	Area A5	Area A10	Area W5	Area W10
Visual*	24	42	72	72
Health and Safety	44	42	32	38
Social**	36	16	6	6
Insects	8	12	34	12
Odors	8	4	16	14
Lack of Recreation	10	18	14	10
Other	7	6	4	5

*Includes muddy or murky water, algae and scum, and garbage and weeds in and around the lake.

**Includes vandalism.

ENVIRONMENTAL SATISFACTION SCALE (ESS)

A general index of satisfaction, a Guttman scale was constructed from the interview responses. Scores on this allow the ranking of subpopulations in terms of their satisfaction or dissatisfaction with the local environment. Moreover, if the items "scale," the relative importance of various features of the environment can be determined. (Because redundant items are discarded, there may be more consensus on the importance of problems than this indicates.) The six questions used in the ESS are given in Table 4. On the ESS, the maximum score is 7, the minimum is 1; higher scores indicate greater satisfaction. The results show that residents closer to Wabukayne are most dissatisfied and those further from Aquitaine least so. Also, Wabukayne residents and those closer to the lakes were more dissatisfied generally. This implies that Aquitaine is a more satisfactory environment, and that problems with such developments will be more generally salient to those living closer to lakes. To determine what factors are related to satisfaction, comparisons were made between satisfaction and various characteristics of the area and population. The results suggest that homeowners, those in professional and managerial occupations, and residents who have lived in the area longer, are more dissatisfied.

MANAGEMENT RESPONSIBILITY

Most residents thought the responsibility of managing and maintaining the lakes should rest with the City (49 percent), and secondly, with the developers (28 percent). There was no significant difference in response from the four areas. Although most residents do not see themselves being responsible as a group for maintaining the lake and surrounding area, 37 percent were willing to be assessed a fixed amount for this purpose and another 10 percent were undecided. Residents living closer to Wabukayne, the most dissatisfied, were most willing to be assessed. Most officials are aware of the management agreements between the City and the developers, and in general it was felt that the maintenance of lakes would be less expensive than a corresponding area of parkland. Most government officials considered the operation and maintenance of the lakes to be the responsibility of the City. The newspaper editor, however, felt that the responsibility should lie with the developers if problems arise due to faulty design. The developers felt that there could be difficulties with maintenance agreements, tying them for up to 10 years, and with the daily aggravation of calls from residents regarding lake problems. They indicated that homebuyers do not expect pollution problems and do expect swimming to be possible in the lakes.

ALTERNATIVE TYPES OF DEVELOPMENT

Residents were asked to compare the Aquitaine and Wabukayne developments, a conventional sewer system, and a less accessible lake on the edge of the development. Seventy percent of residents preferred some form of lake. There was, rather surprisingly, no preference among Aquitaine, Wabukayne, or a lake at the edge of the development. Among officials, the response was much the same, the stormsewer system being considered suitable only if less expensive. However, the newspaper editor opposed locating impoundments at the edge of the development, because it gave a false sense of safety. Officials were asked an additional question: if they would recommend stormwater lakes in other developments or subdivisions. They generally agreed that the lakes are a good

TABLE 3. Structured Questions: Problems with Lakes (percent).

Problem	Area A5	Area A10	Area W5	Area W10	Differences* Lakes	Differences* Distance
Murky Water	59	36	89	76	Yes	No
Scum, Algae	52	52	82	70	Yes	No
Garbage on Shore	34	30	61	40	Yes	No
Garbage in Lake	28	16	63	38	Yes	Yes
Weeds on Shore	8	15	45	33	Yes	No
Weeds in Lake	24	18	31	24	No	No
Rotting Weeds, Fall	4	14	16	14	Yes	No
Health and Safety	57	44	71	68	No	No
Insects	22	30	65	41	Yes	No
Odors	18	16	45	31	Yes	No

*In all cases where the difference was significant ("yes"), problems were greater at Aquitaine (lake) or closer to the lake (distance).

feature for a community, that the Aquitaine approach is better, and that stormwater lakes could be recommended for other suburbs.

TABLE 4. The Environmental Satisfaction Scale (ESS) Items.

1. Are there any problems with sediments in the lake, or murky or muddy water?
2. Are there any problems with garbage or rubbish in the lake, or floating on it?
3. Are there any problems with weeds growing around the shore during the summer?
4. Are there any problems with weeds growing in the lake itself, during the summer?
5. Are there any problems with garbage and rubbish around the edge of the lake?
6. Are there any problems with smells or odors associated with the lake water?

NOTES: (1) Items are ordered such that those who are more satisfied will answer "yes" to fewer questions, beginning from the top, than those who are less satisfied.
(2) The items did not quite scale – the criterion is 90 percent, that reached was 86 percent. Since this was very close, the scale was used in the analysis. With some modification, it could probably be got to scale, and be a very efficient way of measuring environmental satisfaction.

POLICY IMPLICATIONS

The developments have attracted a population of relatively young, professional, white-color and skilled workers with above-average income and education. The lakes are considered attractive by the residents, but although the lakes were a factor in locating in the area, they were probably not most important. Over time, a sense of community develops through contacts with neighbors, the recreational use of the lakes, and through various community associations, especially the residents association.

Satisfaction with the local environment was related to occupation, home ownership and length of residence in the development, with professionals, home owners, and those who live closer to the lake (particulary at Wabukayne) being more dissatisfied. Those who live nearer the lake, particularly Wabukayne, although more dissatisfied, were more willing to pay for maintenance of the lakes, and were more likely to be aware of groups dealing with environmental problems. This may be a way of protecting their rather substantial investment in housing, as lots closer to the lake and parkland generally carry a substantial premium when purchased.

The history of past problems, the responses of residents, and their demographic characteristics suggest that residents' associations or other local groups should be encouraged to act as a liaison between residents, developers, and the City. The residents' concern for safety and environment can be a healthy sign, showing they are aware of the potential problems. Residents' associations could also play an educational role in informing residents of safety hazards, of ways of avoiding or eliminating such hazards, and of drainage or water quality problems, and in giving training in emergency first aid or other useful skills. A periodic monitoring of residents' views on the development could prove useful in locating and solving problems before they become serious. It would be better to develop an ongoing dialogue than suddenly be faced with an angry group mobilized around a particular negative issue.

In addition to their flood and pollution control functions, the lakes provide social and recreational benefits year round, particularly in the summer. Aquitaine tends to attract people from the entire development, because of the greater recreational opportunities. (It must be remembered that the subpopulation areas chosen are not isomorphic with the development boundaries, so that many so-called "Wabukayne residents" are actually living in the Aquitaine development.) Generally, the number of amenities provided seem to be satisfactory, especially at Wabukayne where scenery and natural areas are regarded as important.

Both the Aquitaine and the Wabukayne types of development are popular, even given the problems at Wabukayne.

What this seems to suggest is that various types of developments be built, some natural like Wabukayne, some more manicured like Aquitaine, and some on the edge of the development. This will maintain a variety of choice for would-be residents.

The major problems are visual and safety. There were some social problems mentioned at Aquitaine, although these were more salient for the officials than the residents. When development is completed and the proximity of housing to the lake increases, vandalism will probably be reduced. Stormwater lakes should be designed to maintain high visual quality of both water and shoreline areas. Features such as settling basins at inlets to remove silt, and algae and weed control should be included. Shoreline maintenance should be related to the intended use of the area, with recreational areas requiring maintenance of facilities and vegetation, while natural areas could utilize largely self-maintaining indigenous vegetation cover. Both areas would require periodic litter control measures, and an ongoing monitoring system to maintain water quality.

However, there may be a trade-off between visual quality and safety. The more attractive the water and surrounding areas, the more potential users. For example, the murky water at Wabukayne, while visually less rewarding, may discourage swimming or other contact with the water. Impoundments could, of course, be fenced, but that would increase installation costs, severely reduce aesthetic quality, and fail to prevent dangers and vandalism.

As an alternative, recreational areas associated with impoundments could include separate wading and swimming pools in the park area. This would serve the dual purpose of avoiding many health and safety problems especially for young children, and providing a place for older children and adults to swim, thereby reducing one major source of complaints from residents.

Responsibility for management of the areas and associated costs were generally felt to be the responsibility of the City, and to some extent the developer. Responses of the more dissatisfied residents suggest that they might be willing to bear some of the costs. It is suggested that the various parties involved (developers, city, government agencies and the public) coordinate their efforts from the planning stages onward. For instance, developers might be responsible for design and construction in consultation with City and provincial officials, and for any problems arising in the long run due to faulty design. Once development is complete, the division of responsibilities and costs between the City and developer could be set forth in agreements similar to those currently used for these lakes, for a term agreeable to both parties. However, to include financial details in such agreements, additional data on maintenance costs for different types of impoundments will have to be estimated more closely.

Some form of lake was preferred to conventional storm sewers by both residents and officials, but there was less consensus on the type of lake preferred. Thus, if an impoundment is technically feasible, it should be carefully planned with respect to its uses and limitations. Such planning should take into account both the physical characteristics of the site and the demographic characteristics of the anticipated resident population. Promotional materials for the development should make a conscious effort to describe the functions of the impoundment, and any restrictions on its use.

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